Winnicut River Dam Removal Monitoring Plan

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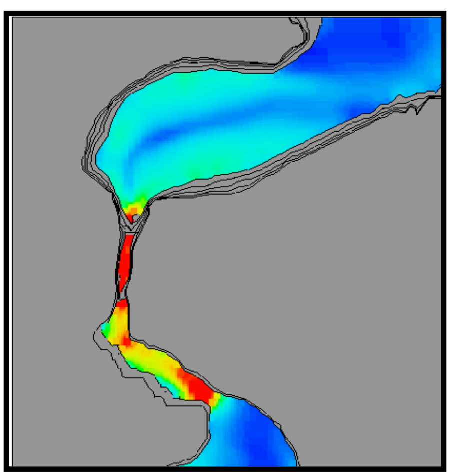
Introduction

The Winnicut River originates in the low-lying hills of New Hampshire's coastal plain, flowing north into Great Bay Estuary. Although a relatively small watershed (17.5 mi^2), the Winnicut River is an ecologically significant tributary to the Great Bay.

In 1957, a low head dam with an adjoining Canadian step-weir fish ladder was constructed in the footprint of a legacy dam, with the intention of benefitting waterfowl and aiding in fish passage. The Winnicut River Dam was located in the tidal portion of the river near the confluence with Great Bay. The dam and its associated fish ladder were owned, operated, and maintained by the NH Fish and Game Department.

The 1957 fish ladder required significant annual maintenance and did not allow herring and other fish to migrate effectively throughout the river system. The Winnicut River provides spawning and rearing habitat for several significant anadromous coastal fish species including *Osmerus mordax* (rainbow smelt), *Alosa spp*. (river herring), and *Anguilla rostrata* (American eel). Once restored, the Winnicut River will be the only coastal river in N.H. with adequate upstream and downstream passage for migrating fish.

A feasibility study completed in 2006 revealed that the Route 33 crossing over the Winnicut River (immediately upstream of the dam) severely narrowed the channel cross section. The study indicated that a velocity fish passage barrier would be created beneath Rt. 33 if the dam were removed. The NHFGD decided to remove the Winnicut River Dam and adjoining Canadian step-weir fish ladder and construct a 132 ft long x 20 ft wide pool-and-weir, run-of river, cast-in-place concrete fishpass beneath the Route-33 Bridge. The new fish pass will maintain the water elevation within the impoundment upstream of Route 33; however, at approximately 18 inches below conditions that existed with the dam in place.



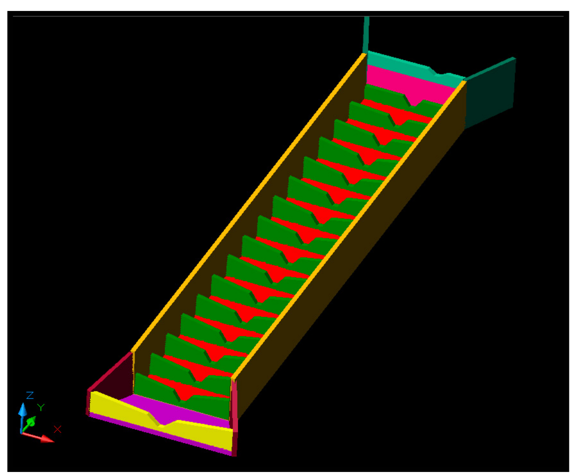


Figure 1. Water velocities (on left) beneath Route 33 are too swift for river herring to pass as indicated by the red as opposed to the slower water velocities indicated in blue. The pool-and-weir fish pass (on the right) will be installed underneath the Route 33 Bridge.

Implementation of the Winnicut River Restoration Project will result in several appreciable changes to the Winnicut ecosystem. These include re-opening 39 miles of riverine habitat within the Winnicut River Watershed, restoring some of the 5,500 ft of riverine habitat disturbed from the creation of the impoundment, and restoring 21,000 square feet of intertidal habitat.

In consultation with the NOAA Restoration Center, monitoring protocols were developed by the NH Department of Environmental Services (NHDES) and the New Hampshire Fish and Game Department (NHFGD). Understanding that the ultimate goal of the Winnicut Dam Removal and Fish Passage Project is to restore fish passage for river herring and to improve spawning habitat for rainbow smelt; the NHFGD will implement multiple monitoring strategies to enumerate the response of target fish species. For the purposes of reporting to the NOAA Coastal and Marine Habitat Restoration Project Grants under the American Recovery and Reinvestment Act, the NHDES with the assistance of NHFGD will only report on the response of the target fish species. The primary reporting elements to NOAA ARRA are:

Table 1. Performance Measures

Objective/Goal Description	Measure	Baseline	Target Year	Project Target	Actual To Date (cumulative)
Miles opened to upstream and downstream fish passage	Miles	0	2010	39.1	
Site Fish Passage	N/A	Does not meet target channel width, slope, max jump height	2010	Meets target channel width, slope, max jump height	
Presence of target fish upstream	Presence/ Absence	Present*	2010	Target Fish Present upstream	
Abundance of smelt eggs	# eggs/ area	0	2010	0.33/ft2	
Presence of smelt in habitats upstream of the former dam	Presence/ Absence	Absent	2010	Target Fish Present	

Although, the main purpose of the project is to restore fish passage; secondary benefits and impacts will result from the project. Therefore, the NHDES and NHFGD have selected additional parameters to characterize the response of the project. Collecting data on additional parameters is critical towards answering questions/concerns from the community about the impact of the project to other species and habitats. The NHDES and NHFGD will also implement protocols for:

- Photo-Monitoring;
- Wetland/Riparian Plant Community Characterization; and
- Water Quality.

Methods and monitoring design for the Winnicut River Dam Removal Monitoring Plan were adapted from the Gulf of Maine Council's Stream Barrier Removal Monitoring Guide (Collins, et al, 2007). Similar to the monitoring framework described in Collins et al, 2007, the Winnicut River Dam Removal Monitoring Plan utilizes transects as reference points for measuring other parameters such as wetland and riparian vegetation.

Fisheries Assessment

Purpose

Diadromous fish play a vital role in the ecological function of the Winnicut River system. From 1957 to 1998, river herring could not pass upstream of the Winnicut Dam, except when NH Department of Fish and Game (NHFGD) employees would manually move them from below to above the dam. Modifications to the Winnicut River fish ladder in 1998 allowed river herring to pass through the Canadian step-weir fish ladder and their populations have gradually increased; however, diadromous fish populations such as river herring, rainbow smelt, and American eel in the Winnicut River remain significantly below historic populations.

The new run-of-river fish pass is designed to provide upstream and downstream passage to the multiple diadromous and resident fish species that utilize the Winnicut River system throughout their life cycle. To be assured the run-of-river fishpass is working as designed, post-removal monitoring of river herring runs will be necessary. One of the other goals of the dam removal project was to restore critical rainbow smelt spawning habitat, which were flooded by the Winnicut Dam Impoundment. When the Winnicut Dam was removed in October 2009, tidal exchange was restored to the former impoundment and habitat, ideal for smelt spawning habitat, was revealed.

The NHFGD will employ methodologies to enumerate both river herring spawning runs and rainbow smelt spawning activity.

Fish Passage

The recently removed Canadian step-weir fish ladder had a single electronic fish counting tube that enumerated fish that ascended up into the Winnicut River impoundment. This data set provides a good baseline of river herring spawning runs prior to dam removal.

The goal of this protocol is to establish a method of enumerating the river herring that ascend the run-of-river fishpass to spawn. A system accurate enough to enumerate or estimate the total number of river herring entering the freshwater system through the new run-of-river fishpass will be employed in 2011. This may be achieved in one of three ways which will be finalized once the fishpass is constructed:

- Conducting time counts at the exit of the fishway;
- A pair of Smith-Root Inc. Model 1101 fish counting tubes; or
- Fyke net a reach of river close to the exit of the fishway.

During periods of normal flow through the fishway the uppermost weir can provide an area where river herring can be observed. Once river herring are observed in NH's coastal fish ladders, daily time counts can be conducted at the Winnicut River fishpass exit weir to provide an estimation of river herring passing into freshwater. The past fish ladder monitoring protocol for NH's coastal rivers prior to the purchase of electronic counting tubes will be instituted. The protocol entailed conducting ten 1-minute time counts at the exit area of the NH coastal fish ladders. An estimation of each river's run was derived by the expansion of the time counts during daylight hours and specific tides if a fish ladder had tidal constrictions.

The preferred sampling method would be to continue utilizing the electronic counting tube(s) to maintain a consistent sampling regimen. However, to be assured all returning river herring pass through the counting tube(s) a "crowder" system will need to be installed on the outside of the exit weir of the run-of-river fishpass. This is typically constructed of aluminum grates that allow downstream flow to pass through. The grates are set at an angle that funnels the returning fish into the counting tubes. In addition, the fish counting box will need to be secured in a box that protects it from vandals and the weather. There is concern whether this can be accomplished with a run-of-river designed fish pass.

If visual obscurity is an issue with the new fishpass design at the exit weir and fish cannot be observed or the electronic counter(s) cannot be installed, a fyke net sample regimen may be developed to determine the annual migratory population within the Winnicut River.

The fish counting method selected would be deployed from approximately April 15th through July 1st in years 1, 3, and 5 after installation of the fishpass. A minimum of one visit per day by at least one person during the river herring migration would be required to perform time counts, calibration counts, or net checks. The date and time of counts will be recorded so data can be expanded or for an electronic device, checked for accuracy. While on site, condition of batteries in equipment will be checked, any accumulated debris from viewing area or entrances to counting tube(s) can be cleared, and proper functionality of the counting equipment can be assessed. In addition, the recording equipment will need to be housed in a secure container to prevent damage from weather or vandals. See Figure 2 for monitoring sites.

Habitat Utilization

The NHFGD has monitored the Winnicut River (below the dam) for presence of smelt eggs during the spring spawning season for many years (Table 2). More recently, the NHFGD has gathered biological samples of smelt during the spawning season as well as various water quality samples in conjunction with a Maine, NH, and Massachusetts tri-state smelt study,

With the Winnicut Dam removed, the former impoundment between the former dam site and the NH Rt. 33 overpass is anticipated to be quality smelt spawning habitat. Previously monitored habitat and the recently restored spawning areas will be checked annually for the next 5 years for the presence of rainbow smelt spawning activity (eggs present). A random sampling technique utilizing a ring of known diameter will be used to assess the utilization and extent of available spawning habitat that is being used and compared to a data time series initiated in 1979. The habitat will be visited once each week at low tide during spring spawning months (approximately March through May), a ring will be randomly tossed 40 times onto spawning substrate, and eggs within the ring will be counted. An estimated total number of eggs per square foot will be calculated for all available spawning habitat within the Winnicut River. Twenty random egg counts will occur below the former dam in previous sampled habitat (and comparable to previous sampling area and technique) and 20 random counts above the former dam in new substrate (Figure 2).

In addition, in years 1, 3, and 5, a small fyke net utilized by the tri-state smelt study will be deployed to capture smelt for the purpose of biological sampling and assessing the age distribution of the Winnicut River smelt spawning population. The fyke net will be set four days each week during the smelt spawning months at one of the sites indicated on Figure 2 as conducted during the tri-state smelt study. All collected smelt will be enumerated and a subsample of biological samples (length, sex, and scales) will be collected to further evaluate the smelt population in the Winnicut River.

Water quality information (turbidity, dissolved oxygen, temperature, conductivity, and pH) will be collected weekly during the remainder of the tri-state smelt project (1-3 years). Upon the completion of the smelt project the data sondes will continue to be used for water quality assessment in years three and five. A data sonde will be placed in a secure section of the tidal river from March through October and a second sonde will be placed in freshwater from June through October.

Figure 2. Winnicut River Dam Removal Project - river herring and rainbow smelt monitoring sites.

Table 2. Smelt egg deposition index as calculated by the mean number of eggs/ft^2 (or cm^2) recorded in sampled rivers in the Great Bay Estuary, NH from 1979-2007.

YEAR	BELLAMY		OYSTER		LAMPREY		SQUAMSCOTT		WINNICUT		AVERAGE	
	/cm^2	/ft^2	/cm^2	/ft^2	/cm^2	/ft^2	/cm^2	/ft^2	/cm^2	/ft^2	/cm^2	/ft^2
1979	1.15	1066	0.57	532	0.32	299	-	-	0.00	0	0.51	474
1980	0.79	729	0.63	582	0.62	571	1.32	1225	0.74	691	0.82	760
1981	3.55	3283	0.21	196	0.59	550	1.68	1562	0.33	305	1.27	1179
1982	0.64	598	0.51	473	1.41	1306	0.43	403	0.04	33	0.61	563
1983	0.74	691	0.26	239	1.05	980	1.38	1285	0.12	107	0.71	660
1984	1.31	1219	1.18	1100	0.70	653	0.62	577	0.08	76	0.78	725
1985*	1.27	1176	0.95	882	1.49	1388	2.22	2063	0.62	577	1.31	1217
1986	0.28	261	0.68	631	0.15	136	0.79	733	0.66	615	1.04	963
1987	0.53	488	0.48	444	0.65	604	0.60	553	-	-	0.47	441
1988	0.37	342	0.67	623	0.22	205	1.20	1117	0.26	240	0.62	576
1989	0.15	141	0.14	130	0.18	166	2.03	1884	0.16	152	0.53	495
1990	0.47	433	0.13	117	0.01	11	0.79	727	0.04	31	0.28	264
1991	0.25	234	0.19	174	0.80	738	1.51	1405	0.00	2	0.55	511
1992	0.17	158	0.22	206	0.16	147	1.61	1497	0.14	131	0.46	427
1993*	0.14	131	0.16	148	0.06	56	1.14	1060	0.03	25	0.30	284
1994	0.26	243	0.60	553	1.08	1006	0.46	431	0.26	239	0.53	494
1995	0.73	673	1.15	1066	1.21	1126	1.92	1634	0.13	119	1.03	923
1996	0.33	312	0.28	256	0.17	156	0.67	625	0.01	11	0.29	272
1997	0.03	25	0.01	11	0.03	26	0.81	749	0.00	0	0.22	203
1998	0.09	86	0.01	5	0.49	453	0.24	223	0.02	13	0.17	157
1999	0.04	39	0.06	59	0.05	50	0.47	439	0.06	62	0.14	130
2000	0.16	147	0.01	12	0.09	85	0.02	201	0.00	0	0.09	89
2001	0.02	21	0.00	1	0.02	15	0.02	21	0.00	1	0.01	12
2002	0.01	12	0.00	0	0.22	206	0.82	763	0.00	0	0.21	196
2003	0.05	43	0.01	12	0.07	65	0.15	140	0.00	1	0.06	52
2004	0.02	21	0.00	1	0.06	55	0.09	90	0.00	0	0.04	33
2005	0.06	61	0.00	5	0.08	76	0.05	48	0.00	0	0.04	38
2006	0.02	16	0.08	69	0.08	71	0.43	402	0.00	2	0.12	112
2007	0.00	2	0.01	6	0.02	14	0.11	97	0.00	1	0.03	25
2008	Monitoring discontinued											
2009	Monitoring discontinued											

+= All values changed from those previously reported, due to a correction in the calculation of the area of the sampling ring used (Values decreased by 41.4%)

*= High water and late ice limited access to spawning areas during spawning.

Establish Transects

As a desk-top exercise, the NH Department of Environmental Services (NHDES) selected transect locations using aerial photos and bathymetry maps of the impoundment. Transects upstream of Route 33 were selected specifically to evaluate riparian vegetation likely to be impacted by an 18 inch drop in water elevation. In the field, transect endpoints were selected based on the availability large tress or otherwise notable landmarks. Because abutting lands to the Winnicut River are privately held, the NHDES elected to not establish permanent monumented end points. In fact, transect selection was, in part, based upon being denied access to private lands. Because changes in stream morphology were not expected, it wasn't necessary to establish georeferenced monumented end-points, a measure more useful for cross sectional and longitudinal surveys.

The transect start and end points were geo-referenced by GPS to allow reproducibility of monitoring efforts in subsequent years (Table 3). In addition, transect endpoints were described in the field notes and marked with flagging. A total of 9 transects were established, 7 of which are upstream of the dam site and 2 were established downstream of the dam (Figure 3).

Table 3. Transect Information

Tran_No	TranLeng	Start_End	Lat	Long	LatLong
1	112	Start	43.037942	-70.847277	43.037942,-70.847277
1	112	End	43.037752	-70.846961	43.037752,-70.846961
2	70	Start	43.037172	-70.847705	43.037172,-70.847705
2	70	End	43.037078	-70.847487	43.037078,-70.847487
3	115	Start	43.036408	-70.847303	43.036408,-70.847303
3	115	End	43.036638	-70.848215	43.036638,-70.848215
4	172	Start	43.035988	-70.847981	43.035988,-70.847981
4	172	End	43.035655	-70.847532	43.035655,-70.847532
5	203	Start	43.034173	-70.848665	43.034173,-70.848665
5	203	End	43.033671	-70.848075	43.033671,-70.848075
6	98	Start	43.032936	-70.849090	43.032936,-70.849090
6	98	End	43.033143	-70.849342	43.033143,-70.849342
7	118	Start	43.032511	-70.850238	43.032511,-70.850238
7	118	End	43.032706	-70.849887	43.032706,-70.849887
8	106	Start	43.031523	-70.849337	43.031523,-70.849337
8	106	End	43.031481	-70.848941	43.031481,-70.848941
9	95	Start	43.030945	-70.849456	43.030945,-70.849456
9	95	End	43.031127	-70.849380	43.031127,-70.849380

Figure 3. Transects established for photo-documentation and to characterize changes in vegetation.

Photo-Monitoring

Purpose

Repeat photography can be useful for tracking features of a river that are visual in nature. This can include changes in riparian vegetation as well as physical/morphological features. The removal of the Winnicut Dam is expected to cause multiple changes in the ecology in part due to an 18 inch drop in the impoundment water level upstream of Route 33 and the complete restoration of tidal flow downstream of Route 33. Repeat photography can provide important qualitative information as well as provide excellent resources for public education.

Methods for photo-monitoring are adapted from the Stream Barrier Removal Monitoring Guide produced by the Gulf of Maine Council on the Marine Environment.

Construction Monitoring

> "Photo monitoring during construction project is equally important as pre-and post-restoration monitoring and can be used to capture short-term changes in ecosystem conditions; inform the efficacy of implementation techniques; confirm implementation success; and support as-built design plans" (Collins et al, 2007).

The project partners (NHDES, NHFGD, Stantec Consulting Services, Inc.) have photo-documented the entire construction project. These photos have proved invaluable in determining percent completion and adherence to the technical specification.

The project partners have also installed a project web camera at the Winnicut Dam Removal site. This includes a web accessed portal for observing photographs of the project time lapsed at 15-minute intervals, as well as allowing a time lapsed video to be produced using the 15-minute interval photographs of the site collected over the duration of the project. Duration of photograph collection for this task will be 1 year. The Dam Cam can be viewed at http://www.earthcam.com/winnicut/ The Dam Cam proved not only to be a valuable outreach tool, but was invaluable for the purpose of construction oversight.

Ecological Characterization

- Photopoints at the Winnicut Site were positioned relative to established transects (as previously described);
- Locations of photo stations were described as distances from the transect end point and bearings from the photo station location;
- Geographic context of each photo was described: left bank, right bank, upstream, downstream;
- Because the photo record will be used to document vegetation changes, photo documentation will take place during the flowering periods of signature riparian plants. Post-restoration photo monitoring will occur 1, 3, and 5 years after the restoration project.
- Photos are labeled according to each transect and bearing. For instance T1W_42 indicates that the photo was taken with a bearing of 42° on Transect 1, which has a endpoint on the west bank.
- The photos are stored in a shared online photo gallery and the specific location of each photo is indicated in Google Maps and Google Earth. The photos can be viewed at http://picasaweb.google.com/riverrestorer/VegetationSurvey#

Figure 4. Photo Monitoring Points Winnicut River Downstream of Route 33

Figure 5. **Photo Monitoring Points Winnicut River Upstream of Route 33**

Table 4. Metadata associated with photo monitoring

Date Taken	Field Monitors	Photo Station ID	Photo Station Description	Compass Bearing (degrees)	Distance along transect	Subject Description
8/13/2009	K Lucey, C Schuman	T1W	Transect Downstream Winnicut Dam	300	135	Looking at W Bank
8/13/2009	K Lucey, C Schuman	T1W	Transect Downstream Winnicut Dam	42	135	Looking Downstream
8/13/2009	K Lucey, C Schuman	T1W	Transect Downstream Winnicut Dam	213	135	Looking Upstream
8/13/2009	K Lucey, C Schuman	T1W	Transect Downstream Winnicut Dam	213	135	Looking Upstream
8/13/2009	K Lucey, C Schuman	T1W	Transect Downstream Winnicut Dam	142	112	Looking SE (Bank?)
8/13/2009	K Lucey, C Schuman	T1W	Transect Downstream Winnicut Dam	212	112	Looking Upstream
8/13/2009	K Lucey, C Schuman	T1W	Transect Downstream Winnicut Dam	212	112	Looking Upstream
8/13/2009	K Lucey, C Schuman	T2W	Transect Downstream Winnicut Dam	212	96	Looking Upstream
8/13/2009	K Lucey, C Schuman	T2W	Transect Downstream Winnicut Dam	212	96	Looking Upstream
8/13/2009	K Lucey, C Schuman	T2W	Transect Downstream Winnicut Dam	24	96	Looking Downstream
8/13/2009	K Lucey, C Schuman	T2W	Transect Downstream Winnicut Dam		96	Panarama
8/13/2009	K Lucey, C Schuman	T2W	Transect Downstream Winnicut Dam		96	Panarama
8/13/2009	K Lucey, C Schuman	T2W	Transect Downstream Winnicut Dam	256	96	Panarama
8/13/2009	K Lucey, C Schuman	T2W	Transect Downstream Winnicut Dam	299	130	Looking W Bank
8/13/2009	K Lucey, C Schuman	T2W	Transect Downstream Winnicut Dam	299	130	Looking W Bank
8/13/2009	K Lucey, C Schuman	T2W	Transect Downstream Winnicut Dam	116	70	Looking East Bank
8/13/2009	K Lucey, C Schuman	T3E	Transect Upstream Winnicut Dam	290	85	Looking W Bank
8/13/2009	K Lucey, C Schuman	T3E	Transect Upstream Winnicut Dam	360	85	Looking W Bank
8/13/2009	K Lucey, C Schuman	T3E	Transect Upstream Winnicut Dam	340	85	Looking W Bank
8/13/2009	K Lucey, C Schuman	T3E	Transect Upstream Winnicut Dam	8	85	Looking Downstream
8/13/2009	K Lucey, C Schuman	T3E	Transect Upstream Winnicut Dam	163	85	Looking E Bank
8/13/2009	K Lucey, C Schuman	T3E	Transect Upstream Winnicut Dam	100	85	Looking E Bank
8/13/2009	K Lucey, C Schuman	T4W	Transect Upstream Dam, Peninsula, Plot 3	60	172	Looking E Bank
8/13/2009	K Lucey, C Schuman	T4W	Transect Upstream Dam, Peninsula, Plot 3	120	172	Looking E Bank
8/13/2009	K Lucey, C Schuman	T4W	Transect Upstream Dam, Peninsula, Plot 3	150	172	Looking E Bank, Oblique
8/13/2009	K Lucey, C Schuman	T4W	Transect Upstream Dam, Peninsula, Plot 3	180	172	Looking Upstream
8/13/2009	K Lucey, C Schuman	T4W	Transect Upstream Dam, Peninsula, Plot 1	280	118	Looking Downstream
8/13/2009	K Lucey, C Schuman	T4W	Transect Upstream Dam, Peninsula, Plot 1	312	118	Looking Downstream
8/13/2009	K Lucey, C Schuman	T4W	Transect Upstream Dam, Peninsula, Plot 1	360	118	Looking Downstream
8/13/2009	K Lucey, C Schuman	T4W	Transect Upstream Dam, Peninsula, From Bridge	102	0	Looking Upstream at Peninsula
8/13/2009	K Lucey, C Schuman	T4W	Transect Upstream Dam, Peninsula, From Bridge	138	0	Looking Upstream at Peninsula
8/13/2009	K Lucey, C Schuman	T4W	Transect Upstream Dam, Peninsula, From Bridge	180	0	Looking Upstream at Peninsula
8/13/2009	K Lucey, C Schuman	T4W	Transect Upstream Dam, Peninsula, From Bridge	220	0	Looking Upstream at Peninsula
8/13/2009	K Lucey, C Schuman	T5W	Transect Upstream Winnicut Dam	332	203	Looking W Bank
8/13/2009	K Lucey, C Schuman	T5W	Transect Upstream Winnicut Dam	280	203	Looking W Bank
8/13/2009	K Lucey, C Schuman	T5W	Transect Upstream Winnicut Dam	260	203	Looking W Bank
8/13/2009	K Lucey, C Schuman	T5W	Transect Upstream Winnicut Dam	220	203	Looking Upstream
8/13/2009	K Lucey, C Schuman	T5W	Transect Upstream Winnicut Dam	360	203	Looking Downstream
8/13/2009	K Lucey, C Schuman	T5W	Transect Upstream Winnicut Dam	30	203	Looking Downstream
8/13/2009	K Lucey, C Schuman	T5W	Transect Upstream Winnicut Dam	72	203	Looking Downstream
8/13/2009	K Lucey, C Schuman	T5W	Transect Upstream Winnicut Dam	200	203	Looking E Bank
8/13/2009	K Lucey, C Schuman	T5W	Transect Upstream Winnicut Dam	142	203	Looking E Bank
8/13/2009	K Lucey, C Schuman	T5W	Transect Upstream Winnicut Dam	103	203	Looking E Bank
8/13/2009	K Lucey, C Schuman	T6E	Transect Upstream Winnicut Dam	352	60	Looking W Bank
8/13/2009	K Lucey, C Schuman	T6E	Transect Upstream Winnicut Dam	174	175	From W Bank looking E
8/13/2009	K Lucey, C Schuman	T6E	Transect Upstream Winnicut Dam	210	175	From W Bank looking E
8/13/2009	K Lucey, C Schuman	T6E	Transect Upstream Winnicut Dam	250	175	Looking Upstream
8/13/2009	K Lucey, C Schuman	T7W	Transect Upstream Winnicut Dam	340	30	Upland Edge Looking E
8/13/2009	K Lucey, C Schuman	T7W	Transect Upstream Winnicut Dam	39	30	Upland Edge Looking E
8/13/2009	K Lucey, C Schuman	T7W	Transect Upstream Winnicut Dam	140	118	Looking W Bank
8/13/2009	K Lucey, C Schuman	T7W	Transect Upstream Winnicut Dam	118	118	Looking W Bank
8/13/2009	K Lucey, C Schuman	T7W	Transect Upstream Winnicut Dam	240	118	Looking W Bank
8/13/2009	K Lucey, C Schuman	T7W	Transect Upstream Winnicut Dam	280	118	Looking W Bank
8/13/2009	K Lucey, C Schuman	T7W	Transect Upstream Winnicut Dam	203	East Bank Creek Edge	Looking W Bank
8/13/2009	K Lucey, C Schuman	T8W	Transect Upstream Winnicut Dam	92	16	Upland Edge Looking E
8/13/2009	K Lucey, C Schuman	T8W	Transect Upstream Winnicut Dam	92	16	Upland Edge Looking E
8/13/2009	K Lucey, C Schuman	T8W	Transect Upstream Winnicut Dam	152	106	Looking Upstream
8/13/2009	K Lucey, C Schuman	T8W	Transect Upstream Winnicut Dam	220	106	Looking Upstream
8/13/2009	K Lucey, C Schuman	T8W	Transect Upstream Winnicut Dam	264	106	Looking W Bank
8/13/2009	K Lucey, C Schuman	T8W	Transect Upstream Winnicut Dam	324	106	Looking W Bank
8/13/2009	K Lucey, C Schuman	T8W	Transect Upstream Winnicut Dam	350	106	Looking Downstream
8/13/2009	K Lucey, C Schuman	T8W	Transect Upstream Winnicut Dam	12	106	Looking Downstream
8/13/2009	K Lucey, C Schuman	T9W	Transect Upstream Winnicut Dam, YMCA Camp	304	115	Looking W Bank
8/13/2009	K Lucey, C Schuman	T9W	Transect Upstream Winnicut Dam, YMCA Camp	232	115	Looking Upstream
8/13/2009	K Lucey, C Schuman	T9W	Transect Upstream Winnicut Dam, YMCA Camp	20	115	Looking Downstream
8/13/2009	K Lucey, C Schuman	T9W	Transect Upstream Winnicut Dam, YMCA Camp	112	120	Looking E Bank

Wetland / Riparian Plant Community Characterization

Purpose

The most pronounced changes to vegetation community structure in the Winnicut River system are likely to be associated with the 18 inch drop of water levels upstream of Route 33 and the re-introduction of tidal mixing downstream of Route 33. Shallow areas dominated by emergent wetland plants are likely to experience a shift in vegetation coverage type and composition. Regions newly affected by more saline waters are likely to transition to more salt-tolerant species of plants. Post-monitoring will also prove essential in the detection and mitigation of invasive plant species that may colonize in newly exposed sediments.

Applied Sampling Protocol

Methods for vegetation monitoring are adapted from the Stream Barrier Removal Monitoring Guide produced by the Gulf of Maine Council on the Marine Environment. The goal of the vegetation monitoring at the Winnicut is to characterize changes in wetland/riparian vegetation community.

1. At each transect (please see above for transect descriptions), field observation will be used to identify coverage types present and will be categorized as either:
   - Forested/Tree (woody-stemmed plants > 20 ft in height, Diameter at breast height > 5 in),
   - Shrub Wetland (woody-stemmed plants between 3-20 ft in height),
   - Emergent Wetland, or
   - Floating/Submerged.
2. At least one sampling station will be randomly chosen in each of the coverage types present. As suggested by the general monitoring protocols:
   - Tree/Forested layers will be sampled with a 9 meter radius,
   - Shrub Wetland layer will be sampled within a 5 meter radius, and
   - Emergent Wetland and Floating/Submerged layers will be sampled using a 1 square meter quadrat.
3. Within each sampling station, species will be identified and percent coverage will be recorded to reflect the categories represented in the Braun-Blanquet cover class scale.
4. Within the tree layer, both canopy coverage and diameter at breast height for use in basal area calculations will be recorded.
5. If invasive species are identified within sampling stations, the species, number of stems, as well as the height of the tallest three specimens of each species will be recorded.

A vegetation survey was conducted on August 13, 2009 prior to the dam removal. The data were reviewed for quality control and entered into Excel spreadsheets. Subsequent surveys will be repeated along the established transects 1, 3, and 5 years after project implementation.

Figure 6. Winnicut Vegetation Transects and Plots -Downstream of Route 33.

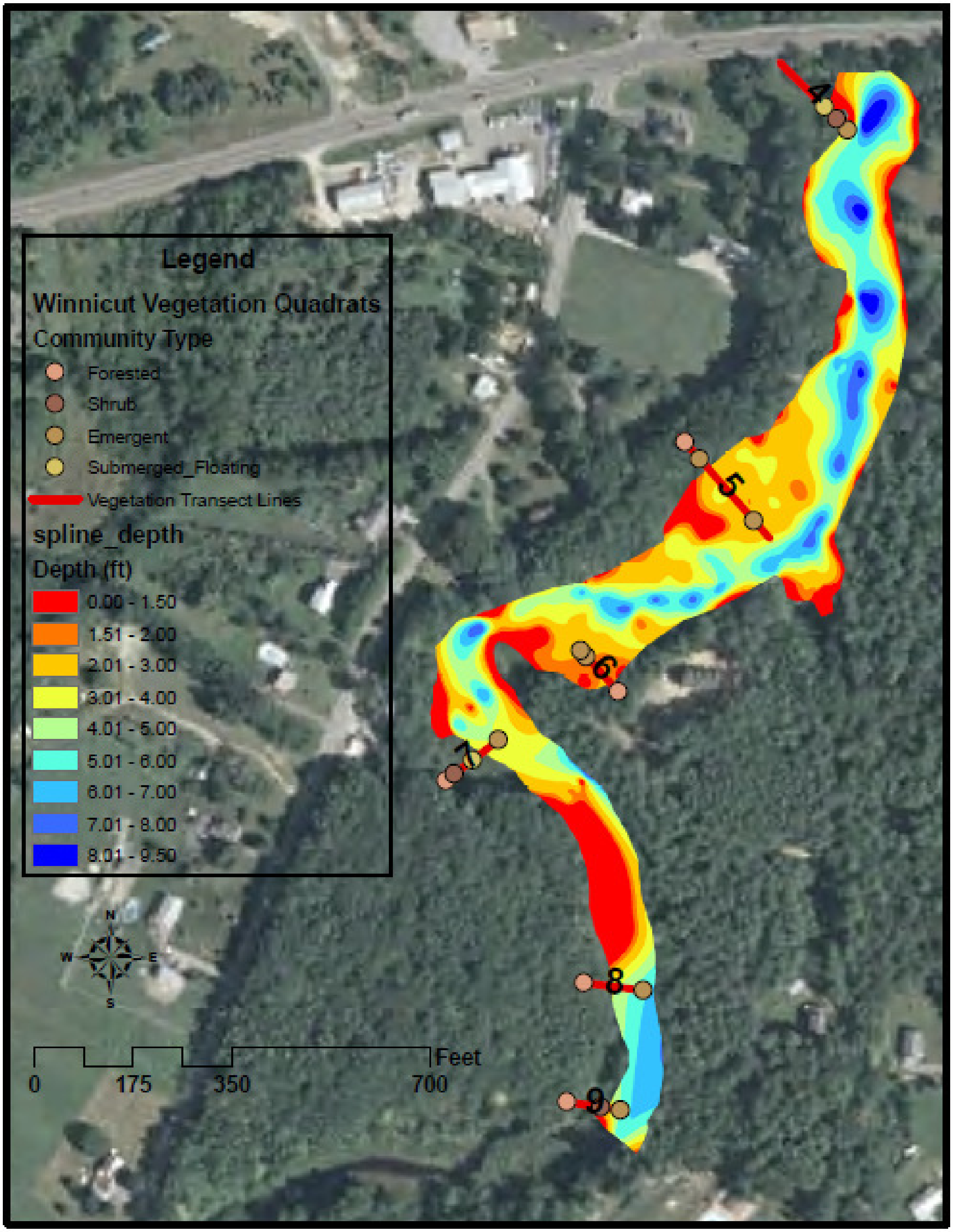


Figure 7. Vegetation transects overlain on a bathymetric map created in September 2008.

DATA SHEETS

Photo Monitoring Data Form

Form #___ of ____

Site Name:	**Stream Name:**	**SITE ID #**
Form Completed By:	**Photographer**	**Date:**
Pre-restoration **Post-restoration** (circle one)		

Photo Station ID #	Photo Station Description	Photo #	Compass Bearing	Time	Cross Section ID #	Distance Along X-Section	Subject Description Upstream or Downstream

General Notes or Comments: (weather, rainfall data, cloud cover, time of sunrise and sunset, other pertinent information

Wetland/Riparian Plant Community Structure Field Data Sheet

Location: ________________________________ **East or West Bank :** ___________ **Town:** ______________________________ **Date:** ________________________________

Transect: __________ **Pre Restoration** ____ **Post Restoration** ____ **Field Monitor(s):** ____

Species Present & Percent Cover

Cover Class	Range (%)	Mean (%)
T	<1	None
1	1-5	3
2	6-15	10.5
3	16-25	20.5
4	26-50	38
5	51-75	63
6	76-95	85.5
7	96-100	98

		Habitat Description		Species	%	Species	%	DBH	Species of Concern & Number of Stems		Height of Tallest Three Species of Concern (cm) 1	2	3
		Tree		Bare Mud									
		Shrub		Water									
		Emergent											
		Floating											
		Submerged											
		Tree		Bare Mud									
		Shrub		Water									
		Emergent											
		Floating											
		Submerged											
		Tree		Bare Mud									
		Shrub		Water									
		Emergent											
		Floating											
		Submerged											
		Tree		Bare Mud									
		Shrub		Water									
		Emergent											
		Floating											
		Submerged											

In the Water: Submerged Aquatic Plants

Common Name	Latin Name	Abbreviation
Bladderwort	*Utricularia vulgaris*	UV
Coontail/Hornwort	*Ceratophyllum demersum*	CD
Milfoil (Variable)	*Myriophyllum heterophyllum*	MH
Pondweed	*Pontamogeton perfoliatus*	PP
Pondweed (Big-Leaf)/Bassweed	*Pontamogeton ampifolius*	PAM
Pondweed (Floating-Leaf)	*Pontamogeton natans*	PN
Pondweed (Ribbon-Leaf)	*Pontamogeton epihydrus*	PE
Water Naiad	*Najas flexilis*	NF
Waterweed/Ditchmoss	*Elodea canadensis*	EC
Wild Celery/Tape Grass	*Vallisneria americana*	VA

On the Water: Floating Aquatic Plants

Common Name	Latin Name	Abbreviation
Duckweed	*Lemna spp.*	LEMNA
Floating Heart	*Myphoides cordata*	NC
Watershield	*Brasenia schreberi*	BS
White Pond Lily	*Nymphea odorata*	NO
Yellow Pond Lily	*Nuphar variegata*	NV
Watermeal	*Wolffia spp.*	WOLFFIA

On the Edge: Emergent Herbaceous Plants

Common Name	Latin Name	Abbreviation
Arrow Arum	*Peltandra virginica*	PV
Arrowhead/Duck Potato	*Sagittaria latifolia*	SL
Blue Flag Iris	*Iris versicolor*	IV
Blue Vervain	*Verbena hastada*	VH
Boneset/Thoroughwort	*Eupatorium perfoliatum*	EP
Bur-Reed	*Sparganium eurycarpum*	SE
Cardinal Flower	*Lobelia cardinalis*	LC
Cattail (Broad Leaf)	*Typha latifolia*	TA
Common Reed	*Phragmites australis*	PA
Grass species	*Poaceae spp.*	POA
Jewelweed/Touch Me Not	*Impatiens capensis*	IC
Joe Pye Weed	*Eupatorium maculatum*	EM
Marsh St. Johnswort	*Hypericum virginicum*	HV
Pickerelweed	*Pontedaria cordata*	PC
Purple Loosestrife	*Lythrum salicaria*	LS
Reed Canary Grass	*Phalaris arundinacea*	PAR
Rush species	*Juncus spp.*	JUN
Sedge species	*Carex spp.*	CAR
Soft-Stem Bulrush	*Scirpus validus*	SV
Swamp Loosestrife	*Decodon verticillatus*	DV
Three-Way-Sedge	*Dulichium arandinaceum*	DA
Water Horsetail	*Esquisitum fluviatile*	EF
Water Smartweed	*Polygonum punctatum*	PPUN
Wool Grass	*Scirpus cyperinus*	SC

Ferns

Common Name	Latin Name	Abbreviation
Ostrich Fern	*Ptertis pensylvanica*	PP

Woody Shrubs

Common Name	Latin Name	Abbreviation
Arrowwood (Northern)	*Viburnum recognitum*	VR
Autumn Olive	*Elaegnus umbellata*	EU
Buttonbush	*Cepahlanthus occidentalis*	CO
Elderberry	*Sambucus canadensis*	SCAN
Glossy Buckthorn	*Rhamnus frangula*	RF
Highbush Blueberry	*Vaccinium corymbosum*	VC
Hobblebush	*Viburnum alnifolia*	VAL
Honeysuckle	*Lonicera spp.*	LON
Japanese Knotweed	*Polygonum cuspidatum*	PCUS
Leatherleaf	*Chamaedaphne calculate*	CC
Maleberry	*Lyonia lingustrina*	LL
Meadowsweet	*Spiraea latifolia*	SL
Multiflora Rose	Rosa multiflora	RM
Northern Wild Raisin	*Viburnum cassinoides*	VCAS
Shadbush/Serviceberry	*Amelanchier arborea*	AA
Sheep Laurel	*Kalmia angustifolia*	KA
Silky Dogwood	*Cornus amomum*	CA
Speckled Alder	*Alnus rugosa*	AR
Spicebush	*Lindera benzoin*	LB
Steeplebush	*Spiraea tomentosa*	ST
Sweet Gale	*Myrica gale*	MG
Sweet Pepperbush	*Clethera alnifolia*	CALN
Winterberry Holly	*Ilex verticillata*	IV
Witch Hazel	*Hamamelis virginiana*	HVIR

Climbing Vines

Common Name	Latin Name	Abbreviation
Climbing Bittersweet	*Celastrus orbiculatus*	COR
Poison Ivy	*Toxidodendron radicans*	TR
Riverbank Grape	*Vitis riparia*	VRIP
Virginia Creeper	*Parathenosisus quinquefolia*	PQ

The Canopy: The Trees

Common Name	Latin Name	Abbreviation
American Basswood	*Tilia americana*	TAM
American Beech	*Fagus grandifolia*	FG
Black Birch	Betula lenta	BL
Black Cherry	Prunus serotina	PS
Box Elder	*Acer negundo*	AN
Eastern Hemlock	*Tsuga Canadensis*	TC
Eastern White Pine	*Pinus strobes*	PS
Red Maple	*Acer rubra*	ARUB
Red Oak	*Quercus rubrum*	QR
Shagbark Hickory	*Carya ovata*	COV
Silver Maple	*Acer saccarinium*	AS
White Ash	*Fraxinus americana*	FA
White Oak	*Quercus alba*	QA
Yellow Birch	*Betula lenta*	BL